

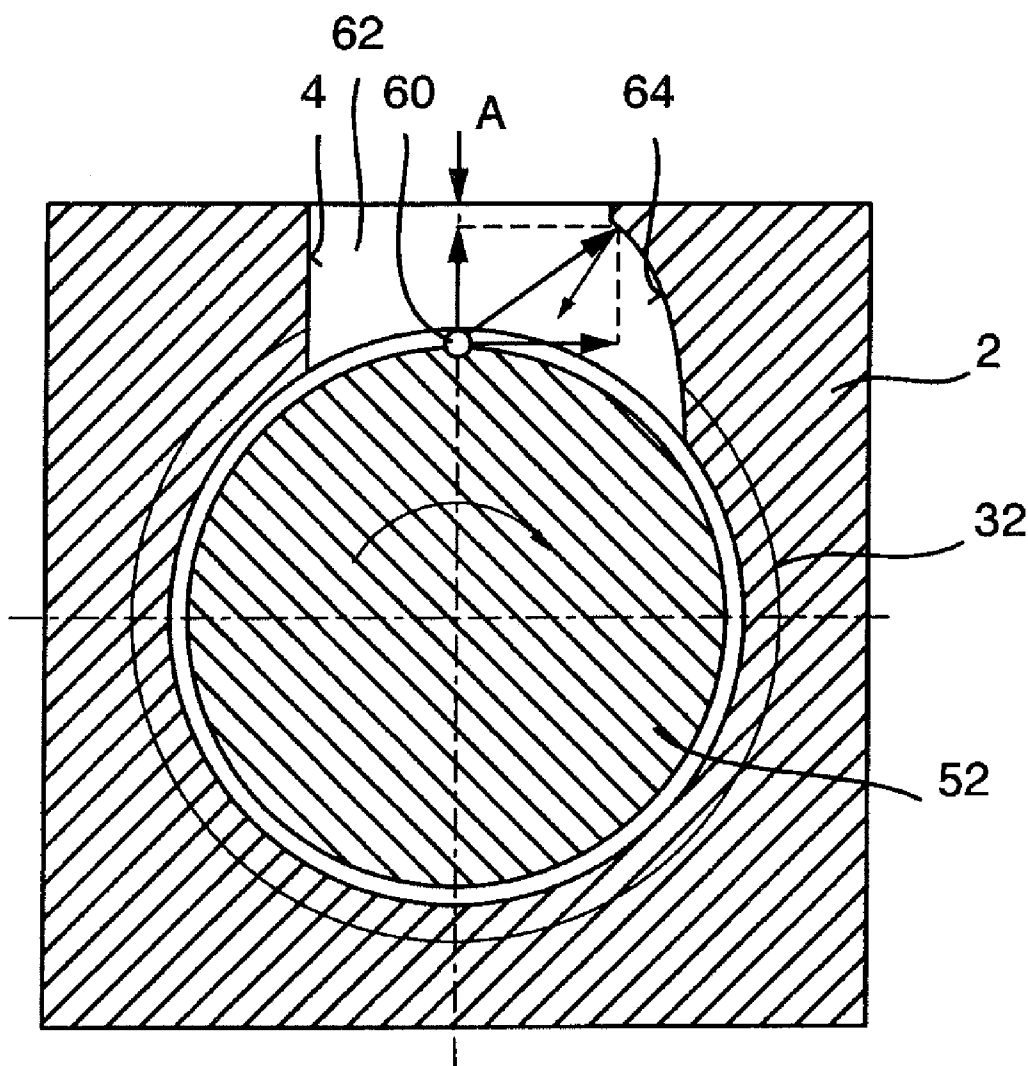


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(19) **United States**(12) **Patent Application Publication**
Koch(10) **Pub. No.: US 2015/0167679 A1**(43) **Pub. Date: Jun. 18, 2015**(54) **VACUUM PUMP****Publication Classification**(71) Applicant: **Pfeiffer Vacuum GmbH**, Asslar (DE)(51) **Int. Cl.**
F04D 19/04 (2006.01)(72) Inventor: **Bernhard Koch**, Barig-Selbenhausen (DE)**F04D 29/54** (2006.01)(21) Appl. No.: **14/571,355**(52) **U.S. Cl.**
CPC **F04D 19/044** (2013.01); **F04D 29/541** (2013.01)(22) Filed: **Dec. 16, 2014**(57) **ABSTRACT**(30) **Foreign Application Priority Data**

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A vacuum pump includes at least one vacuum pump stage having a housing with an inlet, and a rotor having a shaft, with the inlet being arranged radially to the shaft and widening in direction of the shaft.



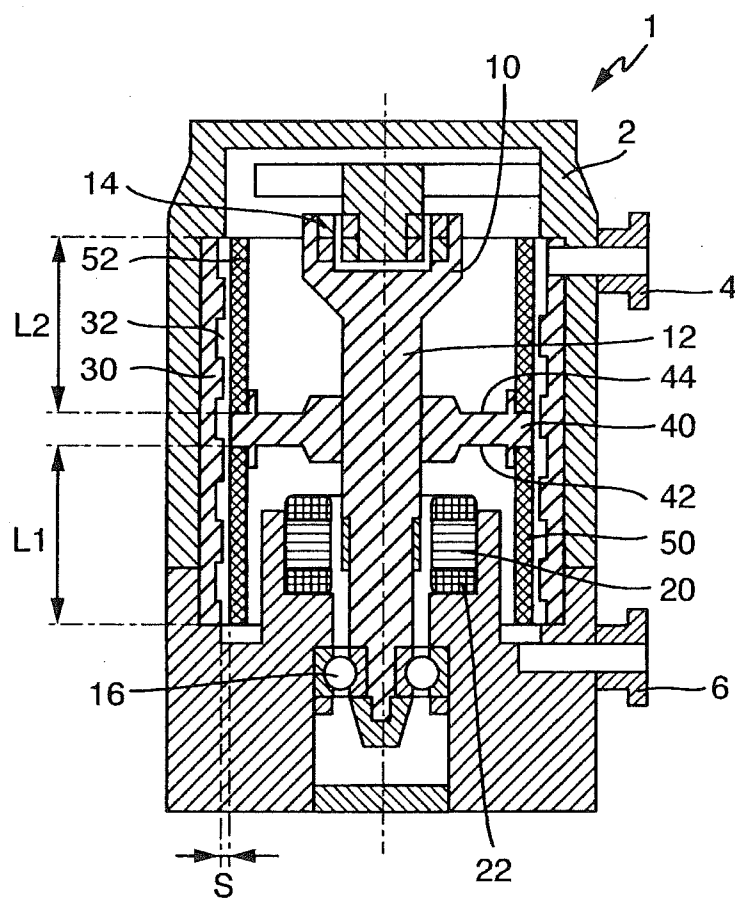


Fig. 1 PRIOR ART

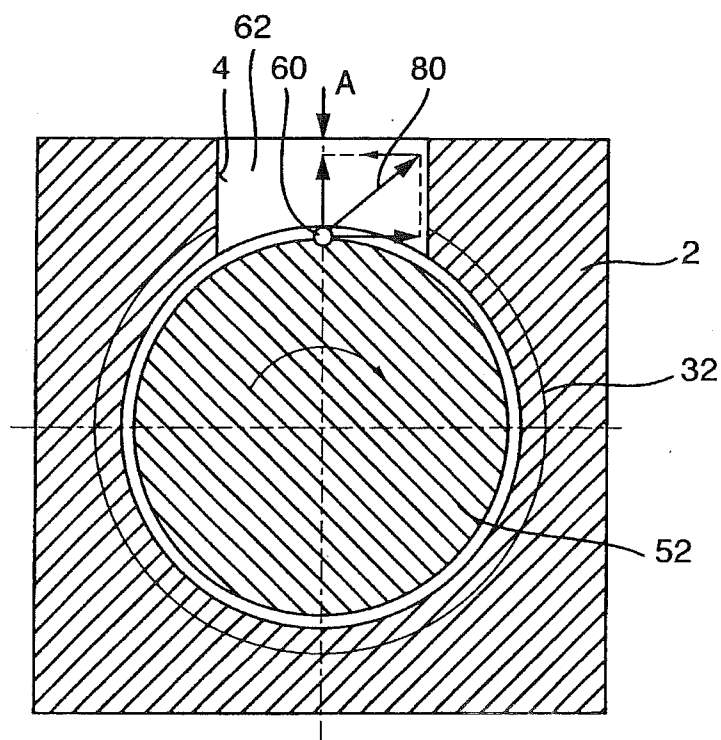


Fig. 2 PRIOR ART

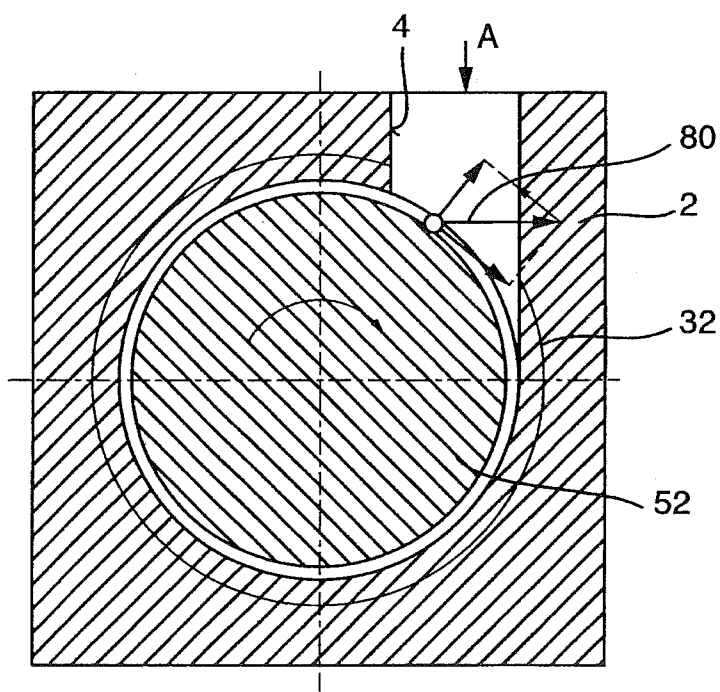
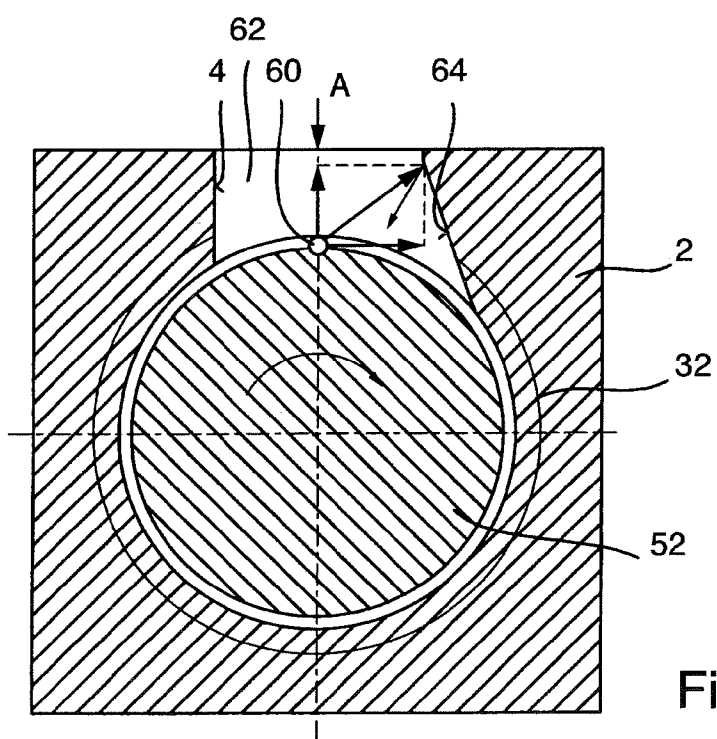
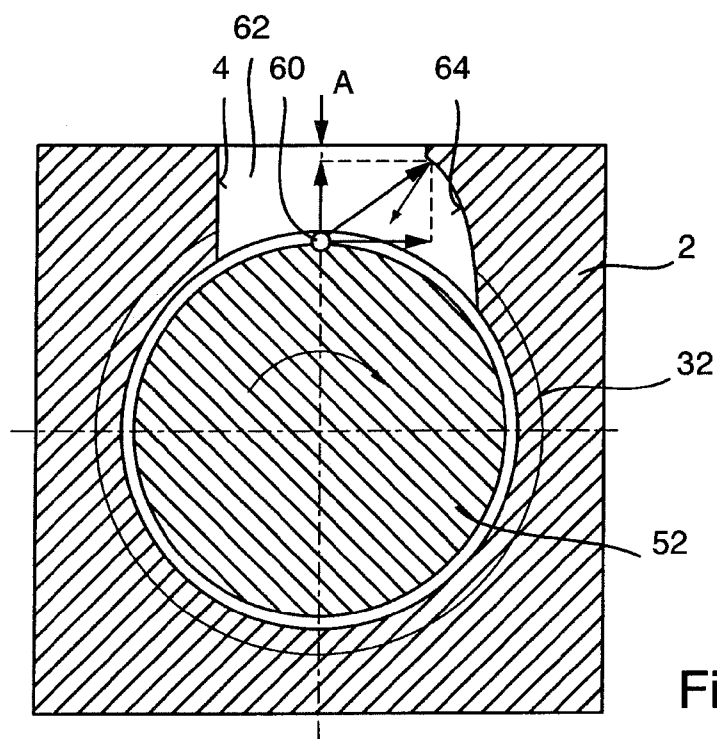


Fig. 3 PRIOR ART



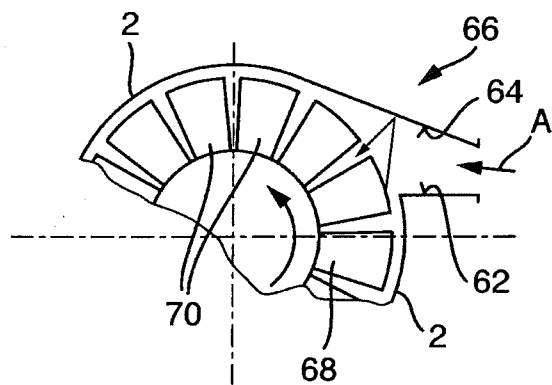


Fig. 6

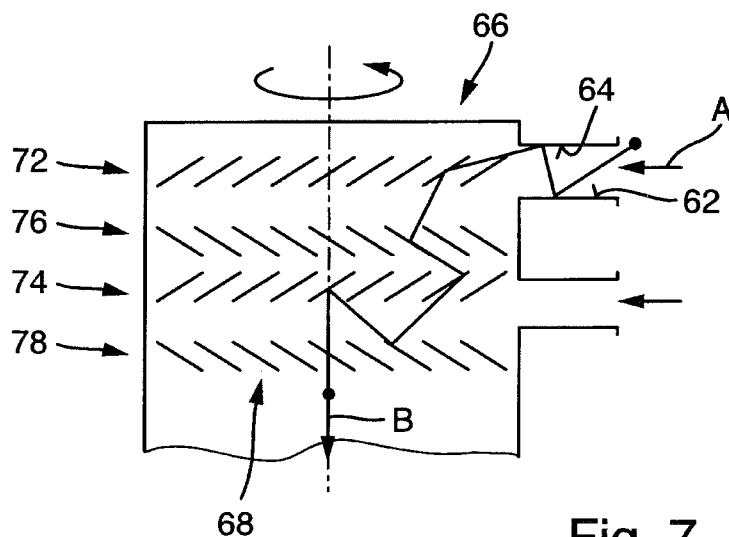


Fig. 7

VACUUM PUMP

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a vacuum pump or vacuum pump stage with a housing that has at least one inlet.

[0003] 2. Description of the Prior Art

[0004] Because of their varied uses in production of vacuum, molecular pumping principles became indispensable to vacuum technology. Ultimately, the pumping effect is based on momentum transfer of a rapidly movable surface to gas molecules, whereby a directed movement is added to a statistical thermal movement.

[0005] Rotatable sleeves prove themselves in vacuum pumps, e.g., in form of a Holweck pump stage. One or a number of sleeves is secured on one side of a hub that itself is provided on a shaft. Such a design is disclosed, e.g., in DE 10 2011 112 689 A1.

[0006] In several applications, the inlet is arranged not axially with respect to the shaft, as in a pump that forms part of the state-of-the art (DE 10 2011 112 689 A1), but radially with respect to the shaft and the rotatable sleeve.

[0007] The drawback of pumps or pump stages which belong to the state-of-the art, consists in that in consideration of a possible movement direction of a gas molecule, it may occur that the molecule does not enter the Holweck channel but rather enters the suction area again in the direction of the recipient. This adversely affects the suction capacity.

[0008] To the state-of-the art (DE 20 2010 012 795 U1) also belongs a vacuum pump in which deflection elements are provided in the inlet region. These deflection elements provide for deflection of particles in the flow or delivery direction of the pump.

[0009] The drawback of these, belonging to the state-of-the art, deflection elements consists in that the mounting of the deflection elements in a vacuum pump is time and costs intensive.

[0010] The object of the invention is to provide a vacuum pump or a vacuum pump stage with a radially arranged inlet in which the suction capacity increases without changing the size of the inlet.

SUMMARY OF THE INVENTION

[0011] The object of the invention is achieved with a vacuum pump or a vacuum pump stage having a housing with at least one inlet, a rotor provided with a shaft, with the at least one inlet being arranged radially with respect to the shaft and with the inlet widening in direction of the shaft.

[0012] The inventive construction of the inlet and, thus, of the suction opening so influences the movement direction of the molecules that they cannot any more leave the suction flange of the pump or the pump stage in the direction of the recipient and remain in the pumping process.

[0013] If one would consider a possible direction of movement of a gas molecules after their contacts with the rotating cylindrical rotor, one would find that the gas molecules if they are not in the vacuum pump or in the vacuum pump stage, most probably, would move above the pump stage and would hit the housing wall. Further movement of the molecules would take place according to a conventional probability distribution.

[0014] As a result of the inventive configuration of the inlet, namely, its widening in the direction of the shaft, the gas

molecules which hit the inner wall, after hitting the inner wall, would be deflected in the direction of the rotating sleeve and would be located with a high degree of probability, in the vacuum pump or the vacuum pump stage. Thereby, the number of gas molecules which are not immediately located in the vacuum pump or the vacuum pump stage, after impacting the inner wall of the widened inlet, would be displaced, with a high degree of probability, into the pump or the pump stage, whereby the suction capacity of the vacuum pump or the vacuum pump stage is noticeably increases.

[0015] The same principle applies to the radial inlet of a turbomolecular pump stage with oppositely rotatable rotor and stator bladings. In this case, the gas molecules are already displaced in the pump active region in the preferred direction, so that the suction capacity also increases in this case. Here, the inlet can be located at the high-vacuum side of the rotor or in the region of the first rotor disc, or in the further path of the pump active structure at an arbitrary point for forming an additional inlet for a split flow pump.

[0016] The inventive configuration not only increases the probability that the gas molecule would necessarily enter the pump active region but also that the gas molecule that is already located in the pump active region, would, after an undesirable exit from the pump active region, be guided anew in the pump active region, so that, it can be displaced therein, thereby additionally increasing the suction capacity.

[0017] According to an advantageous embodiment of the invention, the vacuum pump has at least one Holweck stage with a one-piece rotor and a surrounding it stator, wherein the delivery structure is provided on one of the two parts, or a cross-thread Holweck stage having a one-piece shaft, wherein a delivery structure is formed as an opposite thread structure or rotor of a turbomolecular pump wherein the delivery structure includes at least one rotor disc and stator disc. The inventive configuration with the inlet widening in direction of the shaft can be used particularly advantageously in these vacuum pumps.

[0018] For a single vacuum pump stage, it is advantageous when the vacuum pump stage is formed as a Holweck stage with a one-piece rotor and a surrounding it stator, wherein the delivery structure is provided on one of the two parts, or a cross-thread Holweck stage having a one-piece shaft, wherein a delivery structure is formed as an opposite thread structure or rotor of a turbomolecular pump wherein the delivery structure includes at least one rotor disc and stator disc. The inventive configuration with the inlet widening in direction of the shaft can be used particularly advantageously in such vacuum pump stages.

[0019] According to a further possible embodiment of the invention, the vacuum pump or the vacuum pump stage has a Holweck pump stage comprising a rotor having a shaft, a hub connected with the shaft, and a sleeve connected with the hub and concentric relative to the shaft, wherein the inlet widens in direction of the sleeve. In this embodiment, the gas molecules which hit the inner wall, after hitting the inner wall, would be deflected in the direction of the rotating sleeve and would be located with a high degree of probability, in the vacuum pump or the vacuum pump stage.

[0020] According to an advantageous embodiment of the invention, the inlet is formed as an inlet for guiding gas through the inlet in channels arranged in a rotational direction of the rotor. The advantage of this embodiment consists in that the gas molecules which enter the suction opening, are immediately displaced into the channels arranged in a rotational

direction of the rotor, e.g., of a Holweck stator. The immediate also increases the suction capacity of the vacuum pump or the vacuum pump stage.

[0021] According to a particularly advantageous embodiment of the invention the inlet widens in rotational direction of the rotor.

[0022] The gas molecules when hitting the rotating sleeve, are deflected in the rotational direction, so that it is sufficient to widen the inlet in this direction. The opposite side of the inlet flange can, as known from the state-of-the art, be formed as partially cylindrical.

[0023] According to a still further advantageous embodiment of the invention, in the inlet cross-section, a curved outer profile forms an inlet widening. Basically, the inlet can widen linearly. However, the advantage of the curved outer profile consists in that the profile can so be adapted that the gas molecules would be deflected, with a high degree of probability in the direction of the rotating sleeve after impacting the outer profile, and in the opposite direction. Simultaneously, the curved profile enables to provide a smaller widening of the inlet in the direction of the pump space than is the case with a linear outer profile.

[0024] The inlet can, as discussed above, also widened linearly conically. This configuration can be easily implemented and increases, despite this, the suction capacity of the vacuum pump or the vacuum pump stage.

[0025] According to a possible further embodiment of the invention, the inlet can be so formed that it widens in all directions. It is also possible that the inlet simply widens in the rotational direction of the rotor. If the widening inlet is provided on a side arranged in the rotational direction of the rotor, the costs of forming a widening inlet are reduced.

[0026] Advantageously, the vacuum pump stage is formed as a molecular vacuum pump, in particular, as a Holweck pump. Likewise, the vacuum pump stage is advantageously formed as a molecular pump stage, preferably as Holweck pump stage.

[0027] The inventive configuration of the inlet flanges permits their use as Holweck pump stages in which pump active surfaces are provided in the stator. Likewise, the invention can be used also as used as a Holweck pump stage in which the pump active structures are provided on the sleeve, i.e., on the rotor. Further, the invention can be used in a cross-thread Holweck pump stages in which pump active structures are provided on both the rotor and the stator. The invention can also be used in turbomolecular pump stages in which the pump active structure is formed of rotor and stator blades.

[0028] The novel features of the present invention, which are considered as characteristic for the invention, are set forth in the appended claims. The invention itself, however, both as to its construction and its mode of operation, together with additional advantages and objects thereof, will be best understood from the following detailed description of preferred embodiment, when read with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The drawings show:

[0030] FIG. 1 a cross-sectional view of a prior art vacuum pump;

[0031] FIG. 2 a cross-sectional view illustrating movement of a gas molecule in an inlet of the prior art vacuum pump;

[0032] FIG. 3 a cross-sectional view illustrating movement of a gas molecule in an asymmetrical inlet of the prior art vacuum pump;

[0033] FIG. 4 a cross-sectional view of an inlet of a vacuum pump according to the present invention;

[0034] FIG. 5 a cross-sectional view of another embodiment of an inlet of a vacuum pump according to the present invention;

[0035] FIG. 6 a cross-sectional view illustrating an inlet of a turbomolecular pump stage with a rotor; and

[0036] FIG. 7 a longitudinal schematic cross-sectional view of the turbomolecular pump stage shown in FIG. 6.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] FIG. 1 shows a longitudinal cross-sectional view of a prior art vacuum pump 1. A housing 2 of the vacuum pump 1 has a suction opening, inlet 4 through which a gas is aspirated in the vacuum pump. After compression, the gas is expelled through an outlet 6 of the vacuum pump 1.

[0038] In an interior of the vacuum pump 1, there is provided a rotor 10 that, together with a stator 30, generate a pumping action. The rotor 10 has a shaft 12 supported, at its end adjacent to the suction opening 4, by a permanent magnetic bearing 14. The opposite end of the shaft 12 is supported by a roller bearing 16. This bearing arrangement has an advantage, in comparison with other possible bearing arrangements such as support of the shaft end opposite the suction opening with a flying roller bearing that consists in providing a lubricant-free bearing at the suction side, in a narrow gap due to a simpler rotationally dynamic support, and in shorter constructional length.

[0039] On the shaft, there is provided a permanent magnet 20 that cooperates with an energized drive spool. Thereby, the rotor is set to rotate with an adequately rapid speed. The speed is determined in accordance with used pumping principles and reaches, as a rule, when molecular principles are used, several tens thousand revolutions per minute.

[0040] The stator 30 has, on its surface adjacent to the rotor, a plurality of helical grooves or channels 32.

[0041] A hub 40 is secured on the shaft 12. The hub 40 has a first side 42 and a second side 44 opposite the first side 42. The second side 44 is located adjacent to the suction opening. A first sleeve 50 is secured on the first side, and a second sleeve 52 is secured on the second side. Both sleeves 50, 52 cooperate with the stator 30 and its helical grooves 32 for producing a pumping action in accordance with Holweck principle. The gas stream flows through the suction opening in a groove S between the second sleeve 52 and the stator 30. The first sleeve 50 is arranged downstream, in the flow direction, and, thereby, compresses the stream. Because of the use of sleeves 50 and 52, together with the described gas flow, the manufacturing tolerances affect the groove S to a smaller extent, so that it is more narrow than when comparable single sleeves are used the length of which correspond to the length of the sum of lengths of both sleeves L1 and L2.

[0042] FIG. 2 shows the housing 2 provided with an inlet 4. In addition, FIG. 2 shows a rotatable sleeve 52 and a pumping active structure 32.

[0043] FIG. 2 schematically shows how a gas molecule 60 hits the sleeve 52. Because of a possible movement direction, the molecule might not enter the Holweck channel 32, but rather the suction region 62 in the direction of the recipient, i.e., in direction opposite the direction shown with arrow A.

[0044] FIG. 3 shows a known inlet flange formed with an asymmetrically bored inlet channel. This shape guides the gas molecule 60 in different directions of the inlet 4. The resulting direction is shown with arrow 80.

[0045] FIG. 4 shows the inventive geometry of the inlet 4 which is a further improvement in comparison with the state-of-the art and according to which, the inlet 4 widens in the direction of the sleeve 52. This so influences the direction of movement of the molecule 60 that it cannot any more leave the suction flange of the pump 1 in the direction of the recipient, i.e. in direction opposite the direction shown with arrow A and remains in the pumping process.

[0046] If one would consider a possible direction of movement of the gas molecule 60 after it contacts the rotating sleeve 52, one would find out that the molecule 60, if it is not in the Holweck pump stage, most probably would move above the pump stage and would hit the housing wall 64. Further movement of the molecule would take place according to a conventional probability distribution.

[0047] When the inlet 4 is configured as shown in FIG. 4, the gas molecules which land there, are displaced again into the pump, so that this feature increases the suction capacity.

[0048] FIG. 5 shows a modified embodiment of the invention. According to FIG. 5, the inlet 4 widens linearly conically. According to this inlet geometry, the gas molecules which impact the wall 64 of the inlet 4, also move back in direction of the pumping space so that here also, the pump suction capacity noticeably increases.

[0049] FIG. 6 shows a pump stage 66 of a turbomolecular pump having a suction opening 62. The pump stage 66 has a rotor 68 with rotor blades 70. The gas molecules (not shown) are displaced in direction of arrow A in the pump stage 66. When the gas molecules are deflected by the rotor blades 70 in direction of the outlet, they impinge the inner wall 64 of the suction opening 62 and are guided again in direction of the rotor 68.

[0050] FIG. 7 shows schematically the pump stage 66 with the rotor 68. The rotor 68 has rotor discs 72, 74. There are also provided stator discs 76, 78, with the rotor discs 72, 74 and the stator discs 76, 78 forming opposite rotor and stator bladings.

[0051] A gas molecule that enters the suction opening 62 in direction of the arrow A, is correspondingly deflected by the widening wall 64 of the suction opening 62 and passes through the pump stage 66, leaving the pump stage 66 in direction of arrow B.

[0052] Though the present invention was shown and described with references to the preferred embodiments, those are merely illustrative of the present invention and is not to be construed as a limitation thereof and various modifications of the present invention will be apparent to those skilled in the art. It is, therefore, not intended that the present invention be limited to the disclosed embodiments or details thereof, and the present invention includes all variations and/or alternative embodiments within the spirit and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A vacuum pump, comprising a housing having an inlet, and a rotor having a shaft, wherein the inlet is arranged radially to the shaft and widens in direction of the shaft.

2. A vacuum pump according to claim 1, wherein the vacuum pump comprises at least one of Holweck stage having a one-piece shaft and a stator surrounding the shaft, a cross-thread Holweck stage having a one-piece shaft wherein a delivery structure is formed as one of an opposite thread structure, and a rotor of a turbomolecular pump wherein the delivery structure includes at least one rotor disc and at least one stator disc.

3. A vacuum pump according to claim 1, wherein the vacuum pump comprises a Holweck pump stage having a rotor having a shaft, a hub connected with the shaft, and a sleeve connected with the hub and concentric relative to the shaft, wherein the inlet widens in direction of the sleeve.

4. A vacuum pump according to claim 1, wherein the inlet is formed as an inlet for guiding gas through the inlet in a channel arranged in a rotational direction of the rotor.

5. A vacuum pump according to claim 1, wherein the inlet widens in a rotational direction of the rotor.

6. A vacuum pump according to claim 1, wherein in cross-section, a curved outer profile forms an inlet widening.

7. A vacuum pump according to claim 1, wherein in cross-section, the inlet widens linearly conically.

8. A vacuum pump according to claim 1, wherein the vacuum pump is formed as a molecular vacuum pump.

9. A vacuum pump according to claim 1, wherein the vacuum pump is formed as Holweck pump.

10. A vacuum pump stage, comprising a housing having an inlet, and a rotor having a shaft, wherein the inlet is arranged radially to the shaft and widens in direction of the shaft.

11. A vacuum pump stage according to claim 10, comprising at least one of Holweck stage having a one-piece shaft and a stator surrounding the shaft, a cross-thread Holweck stage having a one-piece shaft wherein a delivery structure is formed as one of an opposite thread structure, and a rotor of a turbomolecular pump wherein the delivery structure includes at least one rotor disc and at least one stator disc.

12. A vacuum pump stage according to claim 10, wherein the vacuum pump stage comprises a Holweck pump stage having a rotor having a shaft, a hub connected with the shaft, and a sleeve connected with the hub and concentric relative to the shaft, wherein the inlet widens in direction of the sleeve.

13. A vacuum pump stage according to claim 10, wherein the inlet is formed as an inlet for guiding gas through the inlet in a channel arranged in a rotational direction of the rotor.

14. A vacuum pump stage according to claim 10, wherein the inlet widens in a rotational direction of the rotor.

15. A vacuum pump stage according to claim 10, wherein in cross-section, a curved outer profile forms an inlet widening.

16. A vacuum pump stage according to claim 10, wherein in cross-section, the inlet widens linearly conically.

17. A vacuum pump stage according to claim 10, wherein the vacuum pump stage is formed as a molecular vacuum pump stage.

18. A vacuum pump stage according to claim 10, wherein the vacuum pump stage is formed as Holweck pump stage.

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